



Automated Detector Commissioning and Early Physics Using Knowledge-Grounded AI



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List of the proposal participants and their organizations:

Physics: E. Lancon, J. Lauret, R. Ma, T. Sakaguchi, G. Van Buren

Computing and Data Sciences: M. Atif, T. Wang

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Research Theme and Goals

The Challenge:

- Modern detectors are complex: ePIC comprises 26+ subsystems.
- Even a single physics task ([e.g., electron ID in the barrel](#)) requires coordinated input from multiple sub-detectors.
- Commissioning usually depends on a small number of experts and requires numerous manual cross-checks, creating integration bottlenecks during start up that can delay physics readiness

What is Detector Commissioning?

- Verification that sub-detectors components are calibrated, aligned, and integrated to produce physics-quality data.
- Requires alignment checks, calibration validation, and reconstruction of known physics signals before physics data taking begins.

This Proposal Focuses On:

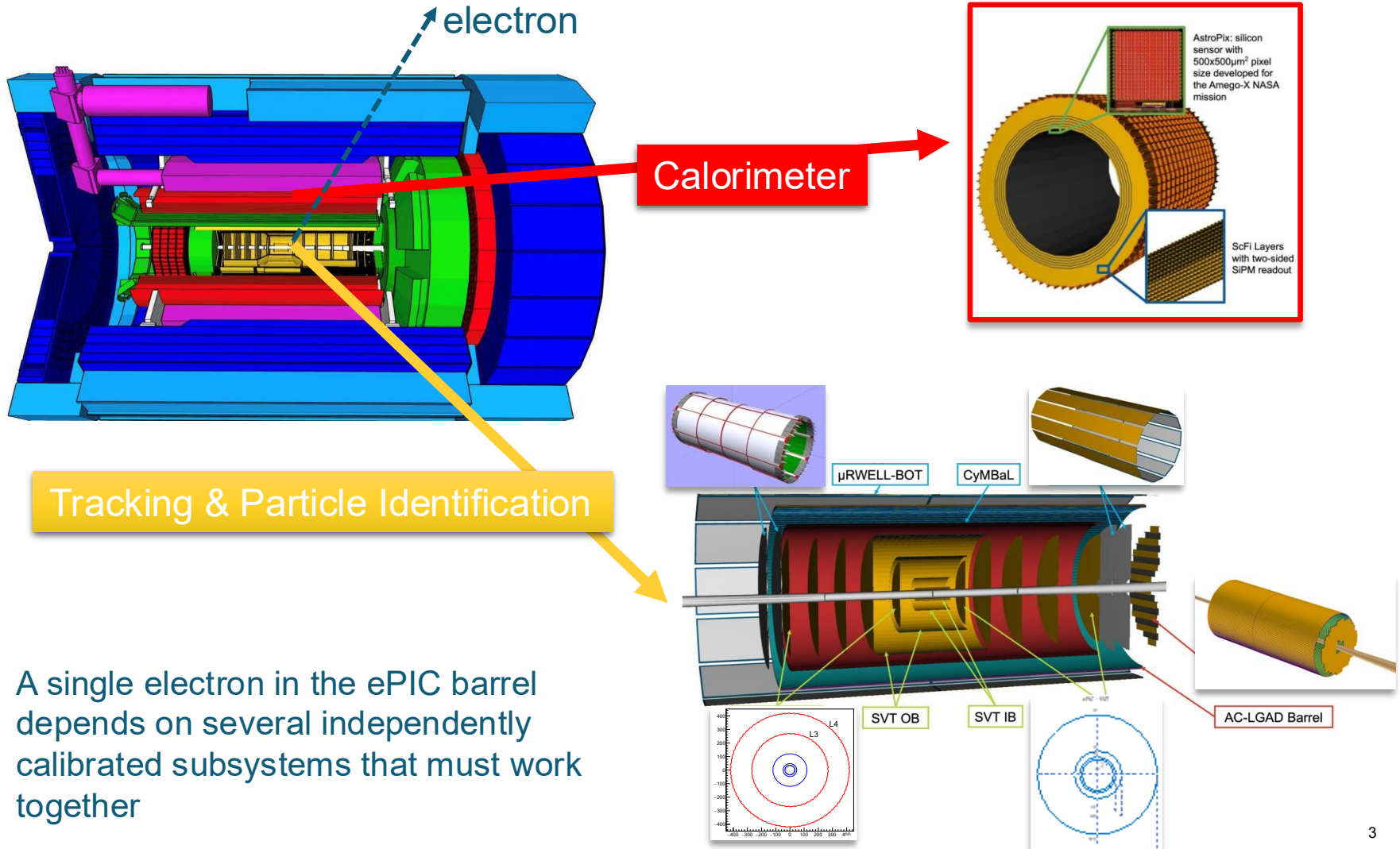
- Developing a knowledge-grounded AI system for integrated detector commissioning and early physics

The Goals:

- Automate commissioning to assist physicists with a comprehensive cross-subsystem approach
- Enable reasoning over detector documentation, sub-component history, geometry, calibration procedures, software frameworks, and physics signals.
- Validate using RHIC data and ePIC simulation.

Detector Complexity Example

Electrons in the ePIC Barrel



A single electron in the ePIC barrel depends on several independently calibrated subsystems that must work together

Scientific Justification and Impact

Holistic Commissioning Tasks:

- **Functionality checks:** Verify detector readout, data quality, and operational status across all subsystems.
- **Calibration, alignment, and operating-point tuning:** AI-assisted identification of inconsistencies and physics-informed recommendations for parameters (e.g., gains, thresholds, HV), with expert validation.
- **Performance validation and stability:** Automated checks using physics signals and cross-subsystem correlations
- **Commissioning datasets:** AI-assisted identification and specification of specialized datasets needed for detector commissioning, including trigger conditions, beam conditions, and target statistics.

Scientific Rationale:

- Many routine commissioning tasks follow documented expert procedures and technical documents
- Encoding this knowledge enables consistent execution and faster integration than manual, subsystem-by-subsystem workflows.

Why This Is Compelling:

- Targets a critical startup bottleneck
- Maintains experts in the loop while automating routine integration and building on technical documentation and operational knowledge.

Impact if Successful:

- Shortens EIC commissioning timelines, accelerates time-to-physics in early EIC running
- Establishes BNL leadership in AI-supported experimental workflows
- Creates reproducible methodology for future experiments

HOW DOES THE PROPOSED RESEARCH ENHANCE THE LAB STRATEGY

Direct support of the EIC, a DOE mission facility.

- Accelerates detector commissioning and early science for the EIC, a flagship DOE user facility hosted by BNL.
- Establishes systematic, reproducible methods for detector commissioning that enable earlier stable detector operation

Advances AI-for-science as a core laboratory capability

- Develops knowledge-based, physics-informed AI integrated into real experimental workflows, aligned with DOE strategic priorities.
- Positions BNL as a leader in AI-augmented experimental physics

Durable institutional impact

- Develops institutional expertise in knowledge-grounded AI systems
- Provides a validated framework exportable to other large-scale experiments

THE RESEARCH TEAM

E. Lancon (PI), J. Lauret, R. Ma, T. Sakaguchi, G. Van Buren (Physics) M. Atif, T. Wang (CDS)

Integrated expertise:

- Experimental physicists: Extensive RHIC and EIC detector experience, calibration procedures, and physics analysis
- AI researchers: Knowledge representation, reasoning systems, LLM-based workflow automation, and uncertainty quantification

Right skill mix: The combination of domain expertise and AI capabilities covers the full development and validation cycle

WHY BNL

Host laboratory for the EIC

- Direct responsibility for detector design, commissioning, and early operations

Proven Detector Integration Leadership

- Decades of experience in commissioning and operating complex RHIC detectors and integrating subsystems

Unique Collaborative Environment

- Co-located detector experts and AI researchers enabling close collaboration,
- Access to DOE Genesis/AmSc infrastructure for scalable deployment

THE RESEARCH TEAM – 1 slide

Name	Expertise
Eric Lancon (PI, PO)	Expert in HEP detector commissioning, calibration, and particle identification at CERN; leadership in large-scale computing and software infrastructure; develops AI methods for data preservation.
Jerome Lauret (PO)	Expert in experiment software frameworks and reconstruction workflows; developed STAR chatbot enabling AI-assisted access to documentation and operational expertise.
Rongrong Ma (PO)	Experienced data analyst at STAR; involved in detector performance studies for ePIC.
Takao Sakaguchi (PO)	Expert in detector construction, commissioning, and data analysis, especially electron/hadron ID at sPHENIX and PHENIX; involved in pFRICH testing for ePIC.
Gene Van Buren (PO)	Extensive experience in detector commissioning, calibration, and operations at RHIC experiments; deep expertise in tracking, detector integration, and early physics performance validation.
Mohammad Atif (CDS)	Specializes in AI and ML for high-performance computing and scientific workflows; develops LLM-based retrieval and generation systems.
Tianle Wang (CDS)	Expertise in workflow engineering and LLM uncertainty quantification for agentic workflows.